The American Fertilizer

94 MARCH 29, 1941 No. 7

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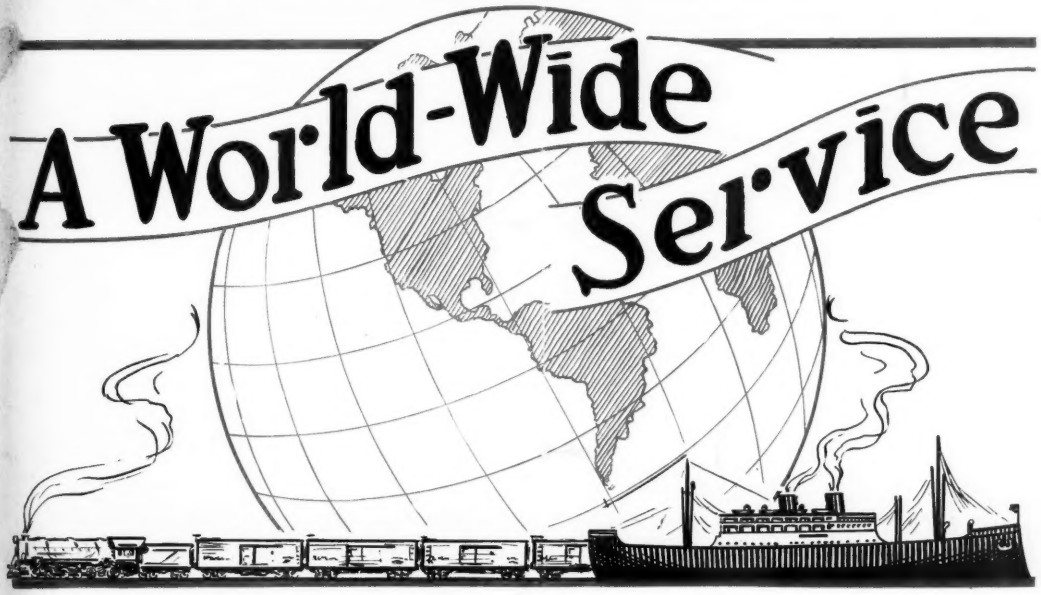

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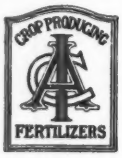
TRADE 

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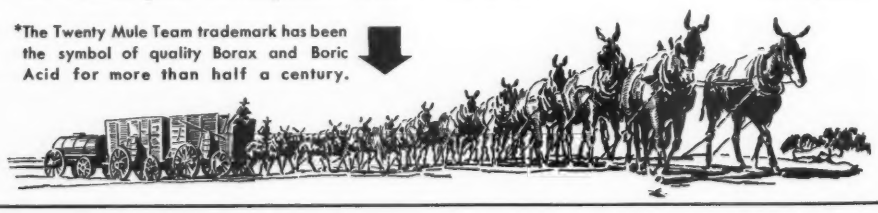

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Vol. 94 MARCH 29, 1941 No. 7

The Status of Minor Elements in Liebig's Day and Recent Developments*

By L. G. WILLIS

Soil Research Laboratory, North Carolina Agricultural Experiment Station, Wilmington, N. C.

IN appraisals of the contribution of Baron von Liebig to the science of soil fertility, there is a strong tendency to emphasize the factual items, to list the elements he identified as essential plant nutrients and those which he thought would be deficient in the soil. Less spectacular, but of much greater fundamental significance was his conclusion that the growth of plants would be limited to the extent that any of these essential elements is deficient in the nutrient medium. It would be expected that, with the development of science and the broadening of experience, the number of essential nutrients would be increased, as would be the list of those deficient in the soil in various parts of the world. The basic principle of minimum plant nutrient requirement would not, however, be subject to such modification.

As he gave his views to the world, therefore, Liebig made no distinction between major and minor elements. The minor element problem did not exist a century ago, not only because it was not an economic problem, but also because the characterization could not be recognized in Liebig's generalization.

Just what constitutes a minor element is still a matter of debate. The term "trace-" or "micro-element" has been proposed as a substitute, to include those elements which are needed by plants only in extremely minute amounts. This puts elements such as magnesium, calcium, and sulphur into an unnamed category while implying that boron, copper, and manganese are required in fertilizers only in very small quantities. From a practical viewpoint there is an inconsistency in this implication inasmuch as the apparent need for compounds containing some of the so-called trace elements is often at the same level as those supplying the major nutrients. No attempt will be made to define the minor elements here, except that the term will be understood to include all essential nutrients except nitrogen, phosphorus, and potassium.

The minor element problem as it is understood today is a product of a development of the past twenty years. "Why," it may be asked, "did eighty years elapse before attention was given to this phase of soil fertility?"

Following the presentation of Liebig's views, Sir John Lawes inaugurated a series of experiments at Rothamstead, England, in an attempt to increase the productiveness of the soil on his estate. Here was introduced the field plat system for the study of fertilizers. The first product of this experiment was the evidence that nitrogen, as well as phosphorus and potassium, as claimed by Liebig, was needed in what came to be known as complete fertilizers.

As other agencies took up the study of soil fertility, the science of agronomy was developed, and for years the principal activity in this science was experimentation with fertilizers. Usually the field work was closely checked by chemical analysis, with the apparent objective of finding a rapid and simple method for determining the fertilizer requirements of the soil.

Information of much practical value was obtained, but in the light of the knowledge of

* A paper presented at the "Liebig Symposium," American Chemical Society meeting, Detroit, September 9-13, 1940.

today the work is defective in many of its scientific aspects. Much attention was given to precision in operation. Plats were laid out by exact measurement, and fertilizer applications were weighed to fractions of a pound. Later a system of replication of plats and the statistical analysis of results was introduced to promote accuracy of interpretation.

At the same time, crude 12 per cent kainit was being identified as potash; dried blood as nitrogen; and 6 per cent superphosphate as phosphoric acid. There can be little doubt that many of the conflicting results of the field plat experiments of the past can be attributed to inaccuracies in the identification of the materials used. Certainly no definite evidence of a need for the minor elements would appear if these were being added indiscriminately in the common fertilizer materials.

Errors in Interpretation of Results

It might be well to point out, also, that a common understanding of the terms "availability" and "deficiency" is often the product of the faulty logic employed in the interpretation of early field plat experiments. For example, the availability of one source of phosphorus might appear greater than that of another if the former contained some other essential element not present in the latter. Inconsistencies in the application of the term "deficiency" can be illustrated in a similar manner.

In general, the basis for all fertilizer experiments was the nitrogen-phosphorus-potassium content of the fertilizer. Only these elements were given credit for the results obtained and, consequently, only these were recognized in fertilizer control laws. The normal result was that manufacturers cheapened their product as much as possible with respect to these elements and, for various reasons, this process generally took the form of eliminating the impurities.

In the refinement of fertilizers, much of the magnesium, boron, and possibly others of the minor elements were lost, with the result that deficiencies of the latter became acute. In a very direct sense, therefore, the recent appearance of the minor element problem is fully as much a product of the imperfection of field plat experiments as it is of soil depletion.

A series of observations can be used to illustrate this development. For years, a disease of tobacco known as sand-drown had been recognized in North Carolina. As the name implies, it was most serious on sandy soils and in periods of heavy rainfall, but it did not appear every year on the same soil. This disease was recognized in 1923 as a symptom of magnesium deficiency, although magnesium had been used in fertilizers as early as 1876. In this experimental work it was demonstrated that the general inclusion of magnesium as an impurity in older fertilizer materials had provided a supply sufficient to serve the needs of plants, except under unusual conditions.

In many of the sparsely populated parts of the world, efficiency in the use of land is not essential. In this country, for example, unproductive land can be allowed to lie idle, and may even be loosely classified as unfit for cultivation, without seriously impairing the national welfare. A dense population cannot afford to abandon land in this way until every method of making it productive has been tried. It is not surprising, therefore, that much of the pioneer work with the minor elements has been done in Europe, especially in England, Holland, Germany, and Finland, while the experimental work in the United States has generally followed European leadership.

Misconceptions Regarding Minor Elements

Although this research activity has produced a comprehensive mass of information on the subject, there are still many misconceptions regarding the minor elements. The proverbial productivity of the limestone soils of Kentucky is commonly attributed to the lime and phosphorus they contain, and human reasoning has no better example of absurdity than the assumption that only lime and phosphate need be supplied elsewhere to duplicate the fertility of these soils. Limestone soils are composed of the materials left after the greater part of the lime has been leached away. These residues, being relatively insoluble under alkaline conditions of leaching, contain many of the minor elements which have been almost completely washed out of acid soils. So, when lime is indiscriminately added to the latter, the effect is to reduce the solubility of many of the essential minor elements, thereby producing a result exactly the opposite of that desired.

With the phosphates, the relation of the minor elements is particularly complex. It is a common experience that superphosphate, which is unquestionably suitable for use in fertilizer, has a very low efficiency rating when used alone in some of the soils of the southeastern states. In the organic sands and mucks of the flatwoods area, superphosphate applied at ordinary rates will reduce the yield of some crops, especially soybeans, and there is some evidence that this effect is not limited to the highly or-

ganic soils. It has long been known that the addition of potash with the superphosphate will prevent the injury, but it is somewhat disconcerting to find that copper sulphate has a similar effect. Where this condition prevails, no method of experimentation yet devised will show the real status of the soil as regards phosphorus deficiency, nor the actual availability of any source of that element. In direct comparisons under these soil conditions, ground phosphate rock has produced greater crop yields than has superphosphate. Obviously the relative efficiency is no criterion of the availability of the phosphorus in these two materials.

Within the range of chemical theory there is nothing that can yet be advanced to explain the parallel effects of potash fertilizers and copper sulphate. As regards the physiological function of copper, it seems to be generally agreed that it acts as a catalyst. Little attention seems to have been given, however, to the possibility that the soil is a biologically active medium, subject to modification by the same catalytic agencies as are the higher plants. In view of many random observations, there can be little doubt that the response of plants to minor elements, as well as to the three major elements, is in part due to effects on the soil.

Add to this complexity, the observation that borax has reduced the severity of the symptoms attributed to magnesium and manganese deficiencies and of wilting, and it is obvious that the minor element problem is no simple matter of independent and additive functions.

The implications of the foregoing observations are too comprehensive for detailed discussion at this time and little help in the solution of the newer aspects of the soil fertility problem can be derived from a review of experimental data based on traditional assumptions. It is becoming increasingly evident, however, that the association of effects with causes has, in the past, been made too often without careful consideration of elementary logic.

Scientific Precision Impossible

In direct conflict with the evidence that the impurities in fertilizer materials have in the past contributed extensively to crop responses, and the certainty that this factor has not yet been entirely eliminated, there has recently arisen a tendency to adopt a form of scientific precision that is definitely unjustified. Crude materials are referred to as though they were approximately pure compounds. Even more objectionable is the tendency to express fertilizer treatments as chemical elements. No scientific objective is served in the translation of superphosphate into phosphorus, of any potash salt into potassium, or of nitrate of soda into nitrogen.

Some difficulty will be found in discussing recent developments regarding the minor elements. With a few exceptions the physiological necessity for many of these has been known for years. Full realization of the extent of deficiencies of these elements is, however, a matter which is still to be attained in many regions.

Even now there is a persistent opinion that these problems exist only in relatively limited areas; yet a need for boron has been identified in Germany and Nova Scotia, Finland and British Columbia, Wisconsin, Florida, and many other localities. Crop response to copper has been noted in the Netherlands, and Michigan, Germany, New York, North Carolina, and Florida. Magnesium deficiency seems to be prevalent on light textured soils which are depleted of other essential elements.

Effect of Environmental Conditions

Within the past few years, attention has been directed to the visible symptoms of minor element deficiencies, although striking responses have been produced where no such symptoms have been observed. Often, too, the symptoms are modified by environmental conditions to such an extent as to be unrecognizable. In full sunlight cotton leaves showing magnesium deficiency are red, whereas in partial shade they are yellow. Manganese deficiency may develop in young soybean plants, but later recovery will produce symptoms that are hardly distinguishable from those of magnesium deficiency.

Zinc deficiency, also, may appear only in early stages of growth and disappear later, making accurate diagnosis possible only during a very short period of growth. If the symptoms of minor element deficiencies are not fully dependable as a guide to the proper use of fertilizer, however, the emphasis given to them recently has been of great service in publicizing the existence of these soil defects and, even though mistakes may be made in diagnosis, a new method of attack on soil fertilizer problems is often prompted by the visible abnormalities of crops.

The minor element problem is not limited to the quantitative features of crop production. In animal nutrition it has been found that mineral deficiencies in natural feeds may include copper, manganese, cobalt, and iodine.

(Continued on page 24)

Fertilizer Papers at A. C. S. Meeting

At the spring meeting of the American Chemical Society at St. Louis on April 7-11, 1941, the Division of Agricultural and Food Chemistry will hold sessions on the last three days of the meeting, at which food problems affecting national defense will be discussed. Among the general papers to be presented on Thursday, April 10th, are several relating to soils and fertilizer practices, abstracts of which are given herewith.

Some Observations of the Effects of Different Soil Conditions on the Mineral Contents of Garden Beans and Peas

Glen Wakeham

Garden beans and peas were planted in plots of "rich" and "poor" soils. The soils and the crops were analyzed for nitrogen, calcium, phosphorus, and iron content. The yield on the poor soils was less than half of that on the rich soil. The poor soil contained less nitrogen, phosphorus, calcium, and iron than the rich soil. The crops from the rich soil, however, were much poorer in the above-mentioned constituents than the crops from the poor soil. The analytical results are given.

The Necessity of Minor as Well as Major Chemical Compounds in a Fertilizer for a Depleted Sandy Loam Soil

J. S. McHargue, R. H. Hageman, W. S. Hodgkiss and E. S. Hodge, Kentucky Agricultural Experiment Station

In a previous report from this laboratory data were presented which indicated that a sandy loam soil was deficient in both major and minor chemical elements as shown by the growth of tomato plants in pot cultures. Experiments under field conditions were made during 1940, using oats as the test crop. Approximately 1/40-acre plots were measured off, the seedbed prepared, and the following fertilized treatments made: check plots, no fertilizer added. Treated plots received manure only, manure and minor elements, sodium nitrate and superphosphate, potassium nitrate and superphosphate, basic slag only, basic slag and minor elements, and the plots were sown with oats.

Samples for chemical analyses were collected from each of the plots six weeks after seeding and at harvest. The samples were analyzed by chemical methods for the major elements, and were also examined with a spectrograph using a quartz prism for the presence of minor elements which could not be detected by chemical methods. The results obtained indicate some beneficial effects on the yield and composition of the oats from minor element treatments. Further experiments under field conditions are contemplated during 1941.

The Comparative Boron Content of Potato Leaves and Tubers Produced Under Different Cultural Conditions

R. B. Carson, W. E. Tottingham and R. MacVicar, University of Wisconsin

Determinations of boron content of different organs of the potato plant have been made with respect to cultural conditions and acceptability of tuber color after cooking. The microcolorimetric method using quinalizarin has been adapted to the photoelectric colorimeter and improved in several respects to increase the accuracy and rapidity of the determination. Leaf, stem, and tuber tissue produced in greenhouse sand culture under varying moisture and temperature conditions showed minor variations in boron content. Increase in boron supply increased the boron content of the leaf more than the tuber or stem. Similar results were obtained in field trials. The boron content of leaf tissue sampled in different regions of the state varied consistently with respect to origin of sample. Consistent differences between varieties were not found. No correlation between cooking quality of the tuber and boron content has been found.

Phosphorus Fixation by Soil Separates and Fractions

A. T. Perkins, C. A. Wagoner and H. H. King

When soluble phosphates are added to the soil, a portion of them combine with it. The purpose of this paper is to study which parts of the soil are most active in fixing phosphorus.

Wabash soil was divided into separates according to particle size and the separates were divided into fractions according to specific gravity. The per cent of the soil appearing in each group was calculated, as well as the surface area per gram, chemical composition determined, and ability to precipitate phosphates.

The phosphate fixing ability was determined by adding soluble phosphates to the separate or fraction under standard conditions and the amount rendered insoluble determined. The results show:

1. The chemical composition of the soil minerals change as the particles become lighter and smaller. The change is gradual except when the particles approach 0.006 mm. in diameter where there is an abrupt change in composition. The smaller particles have larger R_2O_3/SiO_2 ratio than the large particles and

(Continued on page 24)

Justus Liebig, the Man and His Contributions to Human Progress*

By C. A. BROWNE

THIS centenary year of the publication of Liebig's "Organic Chemistry in its Application to Agriculture and Physiology" is an anniversary that is well-deserving of commemoration, for this epoch-making work did more to revolutionize the science of agriculture than any chemical treatise ever written. The book was timely and its reception was immediate and far-reaching, as is shown by the fact that before 1848 it had passed through 17 different editions, 4 in Germany, 4 in England, 2 in America, 2 in France and 1 each in Denmark, Holland, Italy, Poland and Russia. This phenomenal popularity was due in part to the wide interest in scientific agriculture that had been aroused by writers who had paved the way for the appearance of Liebig's book, but it was owing in far greater degree to the world-wide celebrity of the author who, for his discoveries in the research laboratory which he had established at the University of Giessen in 1824, had won the distinction of being one of the most distinguished chemists of the world.

Liebig's contributions to the various fields of organic, analytical, agricultural, physiological, industrial, pharmaceutical and educational chemistry were so numerous that to give an account of his extensive influence in each of these branches of our science would involve the writing of a long series of monographs. A task of this kind cannot be accomplished in one symposium and least of all in a single paper which is limited to a discussion of "Liebig, the Man and his Contributions to Human Progress."

Liebig's character was one of such baffling complexity that the student of his life and social relations is confronted with innumerable contradictions. Liebig, first of all, was a man of stupendous energy and industry. In his case, work was an almost consuming passion. His combined activities as investigator, editor, teacher and writer have never been equaled. His books in their various editions and translations exceed one hundred in number. His published articles in journals, newspapers and other periodicals are so numerous that a complete bibliography of them has never been compiled. His printed correspondence with Wöhler, Berzelius, Renning and other chemists fills many volumes.

Coupled with this trait of energy, Liebig was endowed with an earnestness and enthusiasm which for its contagious quality made him one of the most inspiring chemistry teachers of all time. His school of chemistry, the first to be established for purposes of research, attracted students from every part of the world, all of whom were so stimulated by his energy and zeal that they became the chief agents in spreading his doctrines and in making his name a household word in every country. Measured by the achievements of his graduates, Liebig stands in a class by himself. To mention only a few of his pupils, we note the names of Hoffmann, Kekulé, Pettenkofer, Kopp, Will, Fresenius, Erlenmeyer and Henneberg among Germans; Gerhardt and Wurtz among Frenchmen; Muspratt, Playfair, Williamson and Gladstone among Englishmen; and E. N. Horsford, C. M. Wetherill, Wolcott Gibbs, J. Lawrence Smith, and S. W. Johnson among Americans.

An American Student's Impressions

Liebig's personality has nowhere been more vividly described than in a letter which his American student, E. N. Horsford, later Rumford Professor of the Application of Science to the Arts at Harvard, wrote to the Albany Cultivator in December, 1844, shortly after his arrival at Giessen. Horsford's impressions of Liebig and his laboratory, buried away in the dusty volumes of a neglected agricultural journal, deserve to be rescued from oblivion in this anniversary year and republished for the benefit of chemists of the present generation.

"I have already too long postponed," writes Horsford, "on account of the mighty man whose genius has given such impulse to chemical and agricultural science—the teacher who has congregated in his laboratory, gentlemen from every kingdom of Europe, from Great Britain, the United States and Mexico—the man of whom something is known by every individual who speaks or reads the English language—who has been to organic chemistry what Newton was to mathematics and astronomy—Justus Liebig.

* A paper presented at the "Liebig Symposium" American Chemical Society meeting, Detroit, September 9-13, 1940.

"My first interview with him was in his private laboratory. The reception seemed to me rather that of a military officer than of a scientific man. He was manifestly engrossed with some matters of thought, and while he conducted me through the different apartments of his great laboratory, I could but feel that working and thinking were the characteristic employments here. A gentleman to whom I was introduced spake in an undertone, as if conversation were contraband. Liebig turns to me and says, 'you may converse in English two or three days, but not more.' All this without a smile; decidedly a German mode, thought I, of impressing upon a stranger the necessity of study. I went to seek my lodgings rather depressed.

"A few days rolled away, and I was one of an audience of about a hundred students assembled in the lecture room awaiting the entrance of the distinguished man. The course of organic chemistry was about to commence. Gentlemen in great variety of costume, with note books, pens and ink or pencils were seated, conversing upon various topics, while before us the assistant was just completing his arrangement of substances and apparatus to be employed in the lecture of the day. The hour of the lecture was on the point of striking—the murmer of conversation had subsided to a whisper—presently the whole audience by one impulse rose, and I saw entering and bowing to the salutation, Dr. Liebig. He had just returned from England, where the attentions of the most learned, most wealthy, and most eminent had been lavished upon him, as they have been shared by no man in science in modern times. The published account of the great dinner at Glasgow had reached Giessen. At Darmstadt appropriate honors had signalized his return; and now, with the memory of all these things fresh in his mind and theirs, it was most interesting to look upon the scene which the lecture room presented.

"The apartment in an instant was breathless, and the lecture commenced. What it was about, I was able to see from the formula on the black-board, and from a word now and then which I understood, but I was too much absorbed with the manner, to give much attention to what he said. He is perhaps two or three inches less than six feet, and stands quite erect, though a little rounding of the shoulders from much writing, labor and study might be seen if made the especial object of search. His figure is slender rather than stout, which makes him appear taller than he really is. All his movements, and particularly those connected with demonstration, experiment, or illustration, are graceful to a degree I have not seen equaled in any lecturer. To see him hold in the same hand three glass test-tubes and an equal number of stoppers, while with the other he pours from vessels containing reagents, at first a little excited my surprise.

The portrait that to some extent is circulated in America, represents him much younger than he appears. Another, a lithograph, has recently been published, which is better; but no picture can be made of him. There is an expression of thought in all his attitudes and movements, which I could have scarcely believed upon the mere relation, and which the crayon cannot commit to paper; whether with the chalk and sponge, or with the index finger along the chin and nose, presenting that most singular of all German attitudes, or in gesticulation, or with apparatus, it is all the same. He is all mind—and it beams as distinctly through its corporeal tenement as his chemical compounds are seen through the vessels that contain them. His detail of chemical decompositions and recompositions is clear and expressed without any circumlocution in terms, comprehended by every one. Occasionally these details bring him to review some investigations and theories of his own, and then a new animation is superadded to his ordinary bearing, and the illustrations are dramatic. His large eyes expand, and his features seem to glow. The gesticulations are sometimes so happy and so numerous that I have fancied one might understand some of his themes even if he were unable to hear.

"His notes consist of a few formulas written out upon two or three little strips of paper; and yet his lectures are as systematic as if elaborated with the greatest care. I have heard the remark made that Liebig is not an expounder of chemistry or an operator in chemistry, but is chemistry itself. I am inclined to think the remark encases a German idea, for it has quite eluded my humble American apparatus for sounding. Still it is not difficult to see some of the probable data upon which this notion is founded. For example, he enters the laboratory where he is surrounded by gentlemen engaged in a great variety of investigations. Here is one upon benzoic acid, there one upon hippuric acid, there one upon allantoin; there one upon the cyanogen compounds, here one upon a new gum, here one upon cheese, there others upon bread—and so on, all of them engaged in original investigation. He is ready to tell them the results for which they may look. Such is his familiarity with every fact in known chemistry that its analogies are perpetually present and enable him to premise almost anything with regard to problematical investigations.

"He comes to a gentleman who has a new substance. The Professor directs him to bring a dozen test tubes, and perhaps an equal number of reagents. The unknown substance is in a few moments distributed among the test tubes awaiting the reactions. He goes on through the laboratory repeating similar experiments with other gentlemen; and the next day when he comes round again, if a test tube has been removed from its place, he knows it; moreover, the gentleman who by mistake leaves a process for a night, which ought to have been concluded at once, not unfrequently finds it, on his return the next morning, removed to the Professor's private laboratory. This vigilant surveillance, this powerful local memory, this readiness in affording explanation in all difficult matters connected with chemistry, have induced the expression of the above opinion. However, Liebig has quite deprived the opinion of its poetry, for he has said, for the encouragement of all his pupils, that every fact in the science cost him labor to acquire and labor to retain; and though now ready to pronounce upon the history and properties of every known organic and inorganic compound, he has acquired this prodigious mass of scientific information only with prodigious labor."

Liebig's Impulsiveness

Liebig's enthusiasm for all that he undertook was coupled with an extreme impulsiveness which he found very difficult to curb and which plunged him into all kinds of difficulties. It often led him to a hasty dogmatic statement of faulty generalizations which further experimental work obliged him to modify or to retract. As a result the pages of Liebig's earlier books contain a vast number of mistakes and

erroneous speculations. By constantly subjecting his prematurely announced conjectures to rigid chemical tests and by constant revision, he was enabled, however, to delete many of these blemishes from his later editions.

The precipitateness of Liebig in drawing conclusions caused him to miss the discovery of bromine. He had already isolated this element from a mother liquor of the salt-works of Kreuznach some time before the announcement of its discovery by Balard in 1826, but from hastily conducted tests, which were not wholly conclusive, he assumed the substance to be iodine chloride and the bottle containing it was thus labeled. Liebig's chargin on finding that he had had Balard's new halogen for some time in his possession but under a wrong description plagued him the rest of his life, for it was the nearest he ever came to the discovery of an element. This experience taught Liebig a good lesson, as he himself confessed. He became more careful in drawing conclusions and adopted a more critical attitude in the verification of his experiments. He inculcated this spirit of caution especially in the teaching of his students. His method of laboratory instruction has been well described by his American pupil Professor S. W. Johnson.

"It was in that spirit that Baron Liebig instructed the students who gathered in his laboratory from all quarters of the globe to learn the art of making discoveries in science. They were set to testing the truth of some idea, or the connection of some fact, or else to make new observations and discover new facts to lead to new ideas. It was not the novelty or the glory of discovery, but the genuineness of discovery that was regarded as of first importance. He listened patiently to their accounts of each day's progress, considered their plan of investigation, saw the apparatus or arrangements they devised, witnessed the observations they were led to, and heard the theories they imagined. He encouraged, but he criticized. He asked questions, suggested doubts, raised objections. His students were required not only to collect facts, or supposed facts, and to connect and complement them by comparison, analogies and theories, but they were made to attack their theories in every weak point and to verify or disprove the supposed facts by scrutiny from every side."

Liebig, however, never succeeded in completely freeing himself from the fault of hasty generalizations. He was always more ready to apply keen criticism to the conclusions of other chemists than to some of his own assumptions.

Probably no chemist has ever equaled Liebig as a propagandist. His talent for persuasive and polemic writing was not, however, an unmixed blessing for, while it enabled him to command wide recognition, his dogmatic tone of infallibility and his discourteous language involved him in countless disputes. Few scientific contemporaries of Liebig escaped the vitriolic attacks of his pen. This was especially the case with the physiologists. Chemistry had been regarded by some physiologists for a century or more as an upstart science, an interloper that had no business in encroaching on those borderlands where several fields of knowledge share a common ground. A science of physiological chemistry was anathema to some of these narrow-minded specialists who took particular offense at the title of Liebig's book "Organic Chemistry in its Applications to Agriculture and Physiology." The belligerent spirit of Liebig, however, made no distinctions and the whole class of physiologists had to bear the brunt of his condemnation.

"All discoveries in physics and in chemistry," he remarks, "all explanations of chemists, must remain without fruit and useless, because, even to the great leaders in physiology, carbonic acid, ammonia, acids, and bases, are sounds without meaning, words without sense, terms of an unknown language, which awaken no thoughts and no associations. They treat these sciences like the vulgar, who despise a foreign literature in exact proportion to their ignorance of it; since even when they have had some acquaintance with them, they have not understood their spirit and application."

A general attack of this nature was wholly unwarranted. Carbonic acid, ammonia, and other chemical terms were certainly not words without sense to such a physiologist as Candolle who fully recognized the importance of chemistry in studying the phenomena of plant life and to whom Liebig was especially indebted for some of his ideas. Similar slighting remarks were made by Liebig about botanists and mathematicians. As a result of these censures, which comprised also many eminent chemists, Liebig was deluged by a flood of counter-attacks and rejoinders, many of which were justified. In the words of a well-known contemporary of Liebig, the Scotch agricultural chemist, Professor James F. W. Johnston,

"An unnatural, and in some respects unworthy, excitement found its way into the crucibles and inkstands of Giessen, and Liebig and his pupils, like the wandering knights of old, were shivering their lances against every one they met."

One of the most bitter rejoinders to Liebig's attacks came from the Dutch chemist Mulder of the University of Utrecht who, in a widely circulated brochure, remarked:

"Freedom of scientific opinion has never been understood by Liebig. For years past a tribunal has been established in Giessen before which Liebig is at the same time accuser, witness, public prosecutor, advocate and judge. Before this tribunal a case is rapidly terminated, but grace or justice can *never, never* be

(Continued on page 24)

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Prospective Plantings Report March, 1941

March reports from farmers showing the acreages of principal crops (except cotton) that they plan to grow this year, indicate widespread further adjustments to the agricultural program, shifts between various cash crops in response to price changes and some rather large reductions in spring crops in portions of the West where much improved moisture conditions last fall permitted the planting of an increased acreage of winter wheat. For the country as a whole the most important decreases in plantings now indicated are spring wheat 1,400,000 acres or 8 per cent, grain sorghums 1,300,000 acres or 12 per cent, corn 500,000 acres or 0.6 to 1 per cent, barley 400,000 acres or 3 per cent, potatoes 100,000 acres or 4 per cent, soybeans 700,000 acres or 7 per cent, flaxseed 2 per cent, beans 8 per cent and tobacco less than 2 per cent. The principal increases reported include oats 900,000 acres or 2 per cent, tame hay 800,000 acres or 1 per cent, sweet potatoes 8 per cent, rice 6 per cent, and cowpeas 3 per cent. Reports on peanuts show prospects for about the same acreage as last year. The net decreases indicated in these crops will probably be about offset by an increase of 3 to 4 million acres of winter wheat and rye, for the acreages sown last fall were close to average, while those sown in the fall of 1939 were low because of severe drought conditions.

The 1941 acreage is estimated by the U. S. D. A. Crop Reporting Board from growers' reports and past experience on actual crop production.

Crop	Planted Acreages in Thousands	
	1940	Indicated, 1941
Corn, all	88,143	87,656
All spring wheat	18,547	17,137
Durum	3,431	2,925
Other spring	15,116	14,212
Oats	36,237	37,102
Barley	14,759	14,348
Flaxseed	3,403	3,341
Rice	1,090	1,154
Grain sorghums, all	10,978	9,679
Potatoes	3,104	2,988
Sweet potatoes	772	835
Tobacco	1,427	1,404
Beans, dry edible	2,009	1,855
Soybeans[1]	10,528	9,788
Cowpeas[1]	3,120	3,217
Peanuts[1]	2,390	2,396
Tame hay[2]	61,592	62,398

[1] Grown alone for all purposes. Partly duplicated in hay average.

[2] Acreage harvested.

DR. KNIGHT HONORED

Dr. Henry G. Knight, Chief of the Bureau of Agricultural Chemistry and Engineering, U. S. D. A., has been awarded the medal of the American Institute of Chemists for his accomplishments in the field of agricultural chemistry and research in industrial use for farm products.

CURRENT ISSUE OF BARRETT'S "ARCADIAN GROWER" FEATURES COTTON

With domestic consumption at record levels, cotton growers are entering upon the new crop-season with definite, if conservative, optimism.

Chief factor in the record activity of American cotton mills "is not so much army twills as it is dress goods for spring and summer women's apparel lines," observes "The Arcadian Grower," Barrett's newsy house magazine.

Taking this as its cue, the "Grower" features on its most recent front cover a picture of Mary Martin, of "My Heart Belongs to Daddy" fame—in a dazzling white embroidered cotton evening gown of the latest mode. In three of the Editions are special articles prepared by the National Cotton Council, and the Cotton Textile Institute, describing the progress which has been made in winning for cotton a bigger share of the women's apparel market.

On the agronomic side, all five Editions of the "Grower" carry informative articles on fertilizers and nitrogen—mainly with reference to cotton. For instance, one article features a picture of a cotton *tree* in the West Indies. It brings out the fact that a cotton plant in the Tropics may live for years, and develop into a tree—but as grown everywhere in the south, cotton must complete its life-cycle of growth within those months that are free of frost. The article then describes the service of fertilizers and of nitrogen "in building a better cotton plant in less time."

Another article bears upon the service of commercial nitrogen as a supplement to *legumes*. "Fertilizer Cuts the Weather Gamble" is an interesting interpretation of a Louisiana experiment. And also interesting is a picture-story on how breeding science builds new and better varieties of cotton.

In addition, the "Grower," in its several editions, carries a variety of material of primarily local interest—with the stories told so far as possible in pictures. The editions are distributed as follows: Virginia-North Carolina; South Carolina; Georgia; Alabama; Mississippi Valley.

Indiana Fertilizers, 1940

According to figures compiled by H. R. Kraybill, State Chemist and Seed Commissioner, the use of fertilizers in Indiana during 1940 showed an increase of 26.6 per cent over 1939, totaling 255,059 tons. This tops by about 2 per cent the previous record output of 250,201 tons in 1929.

Of the tonnage reported, 58 per cent was used in the spring and 42 per cent in the fall, as compared with 55 and 45 per cent respectively in 1939.

The 2-12-6 mixture was once more the most popular, accounting for over 50 per cent of all mixed fertilizer tonnage. This analysis sold 118,810 tons, while the next in popularity were 0-12-12, with 30,732 tons and 0-14-6 with 13,592 tons. These were the only grades with sales of over 10,000 tons.

There was a reduction in the number of analyses registered, the figure for 1940 being 116 as against 126 in 1939. However, sales figures show how unnecessary are most of these grades. Only 3 grades sold more than 10,000 tons each, only 19 grades sold more than 1,000 tons each, while 91 grades sold less than 500 tons each and 72 of these sold less than 100 tons each.

Summary

	1940	1939
Total tons reported	251,218	192,507
Tag sales from firms not reporting	3,841	8,913
Total tonnage based on reports	255,059	201,420
Total tonnage from tag sales	280,980	263,145
Raw Materials applied direct	20,646	21,099
Phosphate and Potash Mixtures	68,732	41,902
Nitrogen and Phosphate Mixtures	7	31
Nitrogen and Potash Mixtures	25	—
Complete Fertilizers	160,271	128,728
Miscellaneous	1,537	747

Leading Mixtures (Over 500 Tons)

	1940	1939		1940	1939
2-12-6	118,810	88,350	2-8A*-4I*-6	2,189	....
0-12-12	30,732	9,638	0-21-9	2,069	1,186
0-14-6	13,592	11,836	2-16-8	1,991	1,953
0-8-24	8,456	5,053	0-10-20	1,970	1,134
3-12-12	6,826	4,649	2-12-20	1,538	735
2-8-16	5,828	4,421	2-8-10	1,503	1,937
0-20-20	5,792	4,183	1-11-5	974	1,254
0-10-10	4,595	7,122	10-6-4	843	....
4-24-12	4,571	4,368	4-10-6	840	526
3-18-9	3,754	2,458	6-6A*-6I*-3	691	....
2-12-12	3,648	2,592	2-14-4	649	822
2-12-2	3,224	4,980	4-8-6	638	707
3-9-18	3,113	1,427			

* A, available; I, insoluble.

Maryland Fertilizers, 1940

The sales of fertilizers in Maryland during 1940 showed a slight decline from the previous year, according to figures compiled by L. E. Bopst, Associate State Chemist. Total sales came to 160,315 tons, a drop of 2.6 per cent from the previous year's output, 164,585 tons. The record year was 1937, with 186,285 tons. The drop in the 1940 tonnage is attributed to adverse weather conditions during the spring planting season.

Sales of mixed fertilizers totaled 132,467 tons, with an average analysis of 2.98-9.73-7, compared with an average of 3.18-10-7.13 in 1939 and 2.98-8.26-6.19 in 1938. Analyses containing 20 units or more of plant food sold 87,205 tons, analyses containing 16 to 19 units sold 44,586 tons, while only 676 tons contained less than 16 units.

The 2-12-6 grade supplanted the 2-9-5 mixture as the most popular with sales of 23,432 and 22,474 tons respectively. The 18 analyses recommended by the Maryland Agricultural Experiment Station accounted for 59 per cent of mixed fertilizer sales, as contrasted with 46 per cent in 1939.

Superphosphate, with 11,545 tons, nitrate of soda, with 5,533 tons, and cyanamid, with 1,409 tons, were the only materials used in any great quantity for direct application. Others were bone meal, 731 tons; muriate of potash, 303 tons; kainit, 296 tons.

The total number of analyses registered was about the same as during the previous year. Of the 83 mixtures registered, only 20 had sales of more than 1,000 tons each, while 33 sold less than 100 tons each.

	1940	1939
Firms registered	101	105
Brands registered	886	921
Analyses registered	107	103
Complete fertilizers registered	74	72
Superphosphate and potash mixtures registered	9	12

	1940 Tons	1939 Tons
Total sales	160,315	164,585
Sales by out-of-state firms	15,736	
Complete fertilizers	121,089	126,559
Superphosphate and potash mixtures	11,378	15,018
Nitrogen salts	7,153	901
Superphosphate	11,545	11,633
Potash salts	642	1,117
Nitrogen in mixed fertilizers	3,947	4,508
Phosphoric acid in mixed fertilizers	12,893	14,143
Potash in mixed fertilizers	9,296	10,106

Analyses Showing Largest Tonnage, 1940

Analysis	Units of Plant Food	1940 Tons	1939 Tons
2-12-6	20	23,432	19,218
2-9-5	16	22,474	28,170
6-6-5	17	10,100	14,916
2-8-10	20	9,096	8,955
3-12-6	21	8,919	8,140
0-20-0	20	7,318	6,018
4-8-8	20	6,405	5,231
4-8-12	24	5,638	4,848
4-8-10	22	5,339	5,432
6-8-6	20	4,246	475
0-16-0	16	4,199	5,543
0-14-6	20	3,517	1,738
0-10-10	20	3,469	6,604
5-8-12	25	3,415	4,343

Recommended Fertilizer Analyses for 1940

Analysis	Units of Plant Food	1940 Tons	1939 Tons
2-12-6	20	23,432	19,218
2-8-10	20	9,100	8,955
3-12-6	21	8,842	8,140
0-20-0	20	7,318	6,018
4-8-8	20	6,405	5,231
6-8-6	20	4,246	475
0-14-6	20	3,517	1,738
5-8-12	25	3,241	4,343
5-10-5	20	1,757	1,647
3-8-15	26	1,667	1,673
0-12-12	24	1,173	548
4-12-4	20	788	639
10-6-4	20	398	365
4-16-4	24	183	107
*4-8-12	24	5,539	5,509
*2-8-10	20	565	508
*6-6-8	20	248	378
*2-12-8	22	101	102
		78,520	65,594

* Special fertilizer analyses for tobacco (potash derived from sulphate of potash).

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FERTILIZER MATERIALS MARKET

NEW YORK

Potash Supplies Adequate for Domestic Needs with Export Licenses Probably Difficult. Canadian Sulphate of Ammonia Supply Curtailed. Chesapeake Menhaden Market Opens.

Exclusive Correspondence to "The American Fertilizer."

NEW YORK, March 25, 1941.

In our March 1st issue we advised that with the anticipated production of potash by the newer companies all domestic requirements should be fully taken care of, which disagreed with the opinions of the officials in Washington. However, the latest report from the Bureau of Mines is that the domestic potash supplies should be sufficient to meet domestic requirements. Naturally any large exports would affect the supply for domestic use but from present indications it is going to be very difficult to obtain export licenses for the exportation of this material.

The demand for sulphate of ammonia for export is not as widespread, but nevertheless there is an undercurrent of demand for this material for shipment to Spain and Portugal. Here again no purchases are being made, due to difficulties of obtaining export licenses. The Canadian supply of sulphate of ammonia has been curtailed due to the use of ammonia liquors in Canada for the manufacture of munitions but later in the year there will undoubtedly be some large movements of sulphate of ammonia from Canada. A great deal of this material will undoubtedly move to English territories.

Nitrate of Soda

The movement of the material in the south was slow in starting but the shipping season now seems to be on the way with larger movements. Price is unchanged at $27.00 in bulk with the usual differential for bagged materials.

Superphosphate

Price is unchanged with some demand for export, but in all probability higher prices will prevail for later movement from ports, due to higher cost to producers of their raw materials. This higher cost will be due to higher freight rates being paid for the movement of rock and sulphur.

Potash

Contract movements continue slow with little new business, but there is a feeling there will be some spot demand probably during May.

Nitrogenous

This market is steady, with deliveries moving freely on contracts, but with little new business.

Bone Meal

There are no offerings of foreign bone on the market, due to lack of freight space from points of origin.

Tankage

Our last report contained a typographical error. The market at that time on unground 9/10 per cent material was $2.65 ($3.22 per unit N) and 10 cents and this has been advanced to $2.75 (3.34½ per unit N) and 10 cents. However, sellers are not pressing for business as a higher level is anticipated.

Dried Blood

Offerings are light, with minimum quotations on local production at $2.90 ($3.52½ per unit N) and some producers have ideas up to $3.00 ($3.64½ per unit N). South American is not quoted because shipping space cannot be obtained. Where spot stocks exist, the nominal quotation is $3.00 ($3.64½ per unit N) at the port.

Fish Scrap

A fair business estimated at about 1,000 to 1,500 tons has been done in Chesapeake Bay menhaden scrap on the usual "if made" condition at prices ranging from $4.10 ($4.98½ per unit N) and 10 cents to $4.25 ($5.16½ per unit N) and 10 cents f.o.b. producers' fish factories. There are no offerings on the market but indications are that additional business would be accepted by the producers.

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■

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ATLANTA

Volume of Fertilizer Shipments Satisfactory. Little Buying of Materials. Feed Market Taking Most Fish Production.

Exclusive Correspondence to "The American Fertilizer."

ATLANTA, March 25, 1941.

Mixed fertilizer is now moving in volume throughout this section of the southeast and while the shipping season got away to a late start, it is felt that the tonnage will probably equal that of last year. Some districts seem to be already ahead from a tonnage standpoint but it is too early to forecast what the final figures may be.

The markets all show a little better tone, although future buying in most lines is limited as the trade seems to prefer to await developments rather than commit themselves at this time.

Ocean freights as well as coastal freights are advancing and this will undoubtedly reflect itself in prices as time goes on.

Chesapeake Bay fish scrap sold last week at $4.00 per unit of ammonia ($4.86 per unit N), and 10 cents per unit B.P.L., f.o.b. the Bay, for new crop dried scrap. This demand, however, came from the feed trade. With the price now being paid for dried scrap and meal, most of the fish producers are concentrating on this business and very little acidulated scrap will be produced for the coming season, according to all reports.

The quoted markets are as follows:

South American Blood.—March/April shipment from the Argentine, $2.80 ($3.40½ per unit N), c.i.f.

Tankage.—$2.85 ($3.46½ per unit N) and 10 cents, c.i.f.

Domestic Nitrogenous Tankage.—$1.75 ($2.12½ per unit N), f.o.b. western producing points.

Menhaden Machine Dried Scrap.—$51.00, f.o.b. southern factories.

Acidulated Fish.—From the new catch, $3.00 per unit of ammonia ($3.64 per unit N) and 50 cents available phosphoric acid, f.o.b. fish factories on the South Atlantic Seaboard.

Sulphate of Ammonia.—Good demand from both domestic and export sources.

Nitrate of Soda.—No change in price from importers' and manufacturers' schedule. Fair volume of business is reported.

CHARLESTON

Movement of Fertilizers Increasing in Volume. Some Chemical Materials Scarce. Lack of Freight Space Hinders Imports.

Exclusive Correspondence to "The American Fertilizer."

CHARLESTON, March 25, 1941.

The general movement of mixed fertilizers has begun to get right heavy and probably will reach the peak in the next week or ten days. The movement of nitrate of soda has slowed up. Sulphate of ammonia and potash continue scarce.

Nitrogenous.—Domestic can be obtained around $2.30 ($2.79½ per unit N) at some ports and around $2.25 ($2.73½ per unit N) at other southeastern ports.

Blood.—Around $2.80 ($3.40½ per unit N), Chicago, bulk; $2.65 ($3.22 per unit N), bagged, c.i.f. Atlantic ports, provided freight space is available. Freight is extremely hard to secure right now.

Fish Meal.—This continues very scarce.

Tankage.—Fertilizer grade, around $2.80 ($3.40½ per unit N) and 10 cents, f.o.b. Chicago.

Cottonseed Meal.—Around $30.00 for 8 per cent at Atlanta, and $25.50 for 8 per cent at Memphis.

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BALTIMORE

Spring Shipments Start. Raw Materials in Plentiful Supply. Market on Burlap Bags Steadily Advancing.

Exclusive Correspondence to "The American Fertilizer."

BALTIMORE, March 25, 1941.

Shipments are now starting to move and volume will increase right along and reach their peak during April. In the meantime, manufacturers are bending all efforts getting in orders and not paying much attention to supplies of raw materials which, outside of sulphate of ammonia, are all in plentiful supply.

Ammoniates.—The market on tankage for feeding purposes is ruling a trifle stronger, around $3.10 per unit of nitrogen, with South American dried blood being quoted at $3.25 per unit, but with practically no demand from buyers in this section.

Nitrogenous Material.—Until the spring season is further advanced and buyers are in need of further supplies, not much interest is looked for in nitrogenous, which is still nominally quoted at $2.55 to $2.65 per unit of nitrogen.

Sulphate of Ammonia.—Stocks in hands of manufacturers are ample for current requirements. While there has been but little demand for resale goods for domestic use, offerings are few and far between, although the export demand still continues. However, export licenses are difficult to secure and furthermore there is practically nothing offering for shipment until after the present spring shipping season is over. Last sales for export were around $42.50 per ton of 2,000 lb.

Nitrate of Soda.—The demand continues to improve and the market remains unchanged. Nitrate of soda is still quoted at $29.40 per ton of 2,000 lb., in 100-lb. bags, with usual differential for 200-lb. bags and bulk, ex port warehouses.

Fish Meal.—Stocks are much depleted, and such offerings as are obtainable are firmly held around $60.00 per ton, which, of course, is high in comparison with other organic feeding materials.

Superphosphate. — All manufacturers are now busy making deliveries against previously booked contracts, and the market remains unchanged at $8.00 per ton of 2,000 lb., basis 16 per cent for run-of-pile and $8.50 per ton for flat 16 per cent grade, no charge for excess, both in bulk, f.o.b. producers works Baltimore.

Bone Meal.—Buying interest in bone products is at a minimum, and the market is being

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quoted strictly nominal at $32.00 to $34.00 for 3 and 50 per cent domestic steamed bone meal, while 4½ and 47 per cent South American raw bone meal ranges from $31.00 to $32.00 per ton, f.o.b. sellers works Baltimore.

Potash.—There has been practically no resale demand, as domestic manufacturers of potash, through increase in production, will be able to supply buyers' legitimate manufacturing requirements without any increase in price.

Bags.—The market on burlap during the past few weeks has advanced considerably, due to difficulty in securing supplies of burlap from India, with the result that the present price for plain new 10-oz. bags, basis 40 cut 54 in., is about $168.00 per thousand, which represents a further advance of about $12.00 per thousand since last report, although there is very little buying interest being shown at the present price.

CHICAGO

Trading Light in Fertilizer Organics. Late Demand Expected. Feed Market Continues Active.

Exclusive Correspondence to "The American Fertilizer."

CHICAGO, March 24, 1941.

Buyers and sellers are both apparently displaying a waiting attitude, and consequently trading in organics is very light, at present. Owing principally to weather conditions, it is evident a late season will be experienced in the south, and if that is correct demand, if any, for material is still likely to appear.

Interest in feed material has broadened, as consuming demand continues active. Market is consequently higher.

Nominal prices are as follows: high grade ground fertilizer tankage, $2.20 to $2.25 ($2.67½ to $2.73½ per unit N) and 10 cents; standard grades crushed feeding tankage, $3.10 to $3.15 ($3.77 to $3.83 per unit N) and 10 cents; blood, $3.00 to $3.10 ($3.64½ to $3.77 per unit N); dry rendered tankage, 62 to 65 cents per unit of protein, Chicago basis.

PHILADELPHIA

Active Inquiry on Materials But Little Buying. Limited Offerings on Some Organics.

Exclusive Correspondence to "The American Fertilizer."

PHILADELPHIA, March 27, 1941.

Trading continues slow, although there is considerable inquiry for various materials. However, actual buying and shipping has shown but little improvement. Some materials are in very limited supply and advances in prices are looked for when seasonal buying starts.

Sulphate of Ammonia.—Resales have been reported on basis of $34 per ton at destinations in bulk. There is some inquiry for export at higher figures but inability to secure permits has made trade impossible.

Nitrate of Soda.—Seasonal deliveries are being made.

Fish Scrap and Fish Meal.—Offering limited and market constantly advancing. Sales have been reported at from $59.00 to $63.00, depending on quality.

Tankage and Blood.—Sellers are getting firmer in their views and higher prices are looked for as the season advances.

Nitrogenous.—This material is in fair supply and sales have been reported in the neighborhood of $2.00 per unit of ammonia ($2.43 per unit N).

Bone Meal.—Various grades extremely scarce. 1 and 65 per cent grade held at $41.00 to $42.50 at ports; 3 and 50 per cent grade held at around $34.00; and the 4½ and 50 per cent grade ranging from $32.50 to $34.00 depending on quality.

Potash Salts.—Manufacturers appear well supplied.

PULVERIZED MASCOT LIMESTONE
Trade Mark Registered

MAGNESIUM LIMESTONE
"It's a Dolomite"
American Limestone Company
Knoxville, Tenn.

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the leading name in acid plants

CHEMICO supremacy is based on 26 years of specialized experience in designing and building complete fertilizer plants, acid production and recovery plants, ammonium phosphate plants and ammoniation apparatus. Consult CHEMICO for either new construction or remodeling, whether for large or small requirements.

Your Inquiry is Invited

Chemical Construction Corporation
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CHEMICO PLANTS are PROFITABLE INVESTMENTS

Keyed SERVICE!

Fertilizer plants all over the country—large and small—state their needs and we meet them. Large stocks of seasoned materials and ample modern production facilities enable us to make prompt shipments.

TRIPLE SUPERPHOSPHATE
46 to 48% Available Phosphoric Acid

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We also manufacture
HIGH-GRADE SUPERPHOSPHATE

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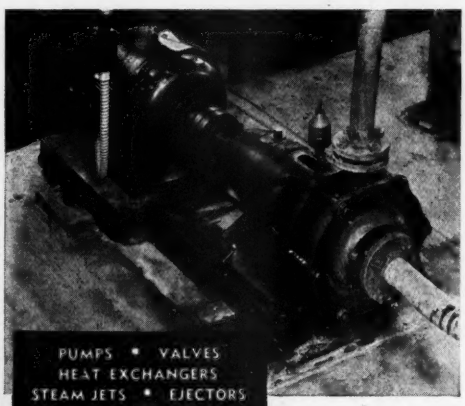
A Mark of FLORIDA TRIPLE PHOSPHATE *Reliability*



IT'S ENGINEERED
TO HANDLE THE JOB

This Model 40 Duriron Pump has just been put in service on sulphuric acid work. It has a normal capacity of 120 gpm. to a 65 ft. head. Maximum capacity of 145 gpm.; maximum head, 80 ft. Other pumps available with capacities to 2500 gpm.; heads to 170 ft.

There are pumps of *Duriron* to meet all demands. For instance, acid tank car unloading and handling chamber acid at all temperatures. And pumps of *Durichlor* are used for transferring hydrochloric acid from the acid plant to other departments for processing by-products.

Write for Bulletin on Equipment desired.

The DURIRON CO., Inc.
Dayton, Ohio

WILMINGTON

Fertilizer Shipments Increasing. Prices Low and Farm Labor Scarce. Summer Menhaden Production on the Market.

Exclusive Correspondence to "The American Fertilizer."

WILMINGTON, March 24, 1941.

The movement of mixed fertilizer has been very slow getting under way, but last week there was quite an upsurge in the movement. The manufacturers are all complaining at the low prices prevalent and are afraid that the labor situation on the farm will curtail to some extent the fertilizer tonnage.

There has been very little activity in the markets, and prices generally are steady. Potash is very hard to get and those fortunate enough to have a surplus are now demanding prices in excess of the scheduled list.

There has been quite a bit of dried fish scrap sold for delivery next summer, prices ranging from $50.00 to $52.00 per ton, buyer's bags, f.o.b. fish factory.

TENNESSEE PHOSPHATE

Shipments of Phosphate Rock to All Consuming Channels Continues Brisk. AAA Asks Bids on Ground Rock for Direct Application.

Exclusive Correspondence to "The American Fertilizer."

COLUMBIA, TENN., March 24, 1941.

The official calendar advent of spring terminated another relic of winter that came in early March with some snow and quite a little cold; but in reality it hardly even momentarily interrupted the speedy tempo of construction and operation activities under way in every direction. The increased tempo of shipments continues to all consuming channels, principally of course to fertilizer factories, to local electric furnace plants, to TVA, blast furnaces, specialty manufacturers and most significant as the usual peak season of that movement, shipments to farmers of finely ground phosphate rock for direct application to the soil.

Shipments in the latter trade continue to run well ahead of same period of 1940, having been 25 per cent ahead in the first half of March, and promising to hold that rate for the balance of March and the month of April.

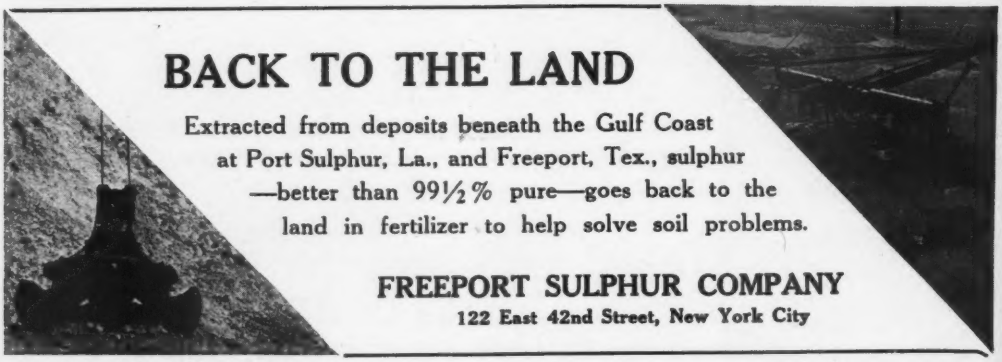
The AAA has added to their grant-of-aid plan for furnishing phosphate fertilizers to farmers, by supplying phosphate rock to eleven counties in Illinois. Bids for ground rock were opened in Washington on March 20th but no information has been received here as to what bids were made or what contracts were awarded.

The specifications fixed by AAA were for low-grade waste product not susceptible of being made into superphosphate. As the benefit payments are based on a fixed amount of phosphate rock, regardless of how high grade or low coarsely ground, the farmer will not get the proven benefit of the superiority of the finely ground high-grade material.

The high grade producers did not bid, and it is not thought that the regular sellers of the low grade product made any bid, but several producing miners with low grade material they desired to get rid of, are understood to have bid.

I. A. C. - UNION POTASH MERGER DELAYED

The meeting of the stockholders of the Union Potash & Chemical Co., which was called for March 11th to vote on a proposed merger with the International Agricultural Corporation, was postponed to give the officers of the Union Company an opportunity to seek better terms for their stockholders. Opposition to the original terms of the merger had de-


BACK TO THE LAND
Extracted from deposits beneath the Gulf Coast at Port Sulphur, La., and Freeport, Tex., sulphur —better than 99½% pure—goes back to the land in fertilizer to help solve soil problems.
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122 East 42nd Street, New York City

For over 20 years we have served the Fertilizer Industry

ACID-PROOF CEMENT
Ready Mixed—For Immediate Use
Packed in 250-lb. Steel Drums
Dry-Packed in 100-lb. Bags

CHEMICAL PUTTY
Stops Acid, Gas and Water Leaks

QUARTZ PEBBLES
Graded to Size

FILTER GRAVEL, FILTER SAND

ACID VALVES

SOUTHERN DISTRIBUTORS OF
CALGON (Sodium Hexametaphosphate)

ACID BRICK, SPIRAL RINGS

Charlotte Chemical Laboratories
INCORPORATED
Laboratories, Plant, Office
CHARLOTTE, N. C.

WILLIAM C. WELLMANN
BROKER
Baltimore, Maryland

Specializing in

Sulphate of Ammonia
Low Grade Ammoniates
Superphosphate
Sulphuric Acid
Bags

Inquiries and offerings invited

KEYSER BUILDING

SPECIFY
THREE ELEPHANT
BORAX
REG. U.S. PAT. OFF. REG. U.S. PAT. OFF.

. . . . WHEN BORON IS NEEDED TO CORRECT A DEFICIENCY OF THIS IMPORTANT SECONDARY ELEMENT

Agricultural authorities have shown that a lack of Boron in the soil can result in deficiency diseases which seriously impair the yield and quality of crops.

When Boron deficiencies are found, follow the recommendations of local County Agents or State Experiment Stations.

Information and references available on request.

AMERICAN POTASH & CHEMICAL CORPORATION
70 PINE STREET, NEW YORK CITY
Pioneer Producers of Muriate of Potash in America
See Page 4

veloped among holders of a minority portion of the Union stock. The I. A. C. owns about 95 per cent of the preferred stock and 56 per cent of the common stock of the Union company.

According to press reports, the Smith-Douglass Co., Inc., has contracted for a new sulphuric acid plant at Norfolk, Va., to cost about $250,000.

JUSTUS LIEBIG, THE MAN

(Continued from page 11)

obtained there. From this tribunal even the purest innocence is never dismissed without being whipped and branded; and for this purpose again Liebig holds also the office of executioner."

The literature of Liebig's polemics with Mulder, Berzelius, Dumas, Wolff, Lawes, Meissner, Marchand, Mitscherlich and others would fill several volumes. It was in vain that his gentle friend Wöhler urged him to desist in a passage as remarkable for its wisdom as for its philosophic humor:

"To make war upon Marchand (or any one else, for that matter) is of no use. You merely consume yourself, get angry, and ruin your liver and your nerves—finally with Morrison's Pills. Imagine yourself in the year 1900, when we shall both have been decomposed again into carbonic acid, water and ammonia, and the lime of our bones belongs perhaps to the very dog who then dishonors our grave. Who then will care whether we lived at peace or in strife? Who then will know anything about your scientific controversies—of your sacrifices of health and peace for science? No one? But your good ideas, the new facts you have discovered, these, purified from all that is unessential, will be known and recognized in the remotest times."

(To be continued in the next issue)

FERTILIZER PAPERS AT A. C. S. MEETING

(Continued from page 8)

the lighter particles a larger ratio than the heavy.

2. Phosphate fixation is noticeably increased as particle size decreases. The change is gradual except when the particles approach 0.006 mm. in diameter, where there is an abrupt change.

3. Among the coarser particles the phosphate fixation is greater by the light minerals than by the heavy minerals.

4. The coarse particles fix considerably more phosphate per surface area than the fine particles.

5. In general the larger the R_2O_3/SiO_2 ratio, the greater the phosphate fixation.

THE STATUS OF MINOR ELEMENTS IN LIEBIG'S DAY AND RECENT DEVELOPMENTS

(Continued from page 7)

Some of these elements may be needed even where the growth of feeds is abundant. Soybeans will often make a luxuriant growth on soils where some of the truck crops fail unless copper is added, and rye grows well where manganese deficiency will prevent the growth of oats. In New Zealand, supplementary feeding with cobalt is needed even where cattle graze on abundant pasturage. This evidence of the qualitative factor broadens the scope of the minor element problem to include almost every phase of production in agriculture.

Economically, the recognition of minor element function has been of enormous significance. Many areas are favorably situated as regards climate and accessibility to markets, yet tender and perishable agricultural crops have not been produced because of unfavorable soil conditions. Attempts to grow truck crops on the Atlantic seaboard have, in many localities, been unsuccessful until the minor element factor was brought into the picture.

Prior to this time, recommendations had been made regarding the need for lime on the assumption that a low degree of acidity was needed for these crops. In many cases, however, liming had brought disastrous results, making the land unproductive for nearly all crops, until it was learned that the adverse effect of lime could generally be corrected by the use of one or more of the minor elements. Before this discovery was made, the results of field plat experiments had apparently established the fact that these soils would not tolerate more than very light applications of lime, and the South seemed committed to an acid soil type of farming. Now there is no dependable information on the optimum rate of liming or the most desirable pH level for any crops grown on these soils, although experiments

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Dependable for Fifty Years
Founded 1834
All-Steel Self-Contained Fertilizer Mixing Units
Batch Mixers—Dry Batching Pan Mixers—Wet Mixing
Swing Hammer and Cage Type Tailings Pulverizers
Vibrating Screens Dust Weigh Hoppers Acid Weigh Scales
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MENTION "THE AMERICAN FERTILIZER" WHEN WRITING TO ADVERTISERS.

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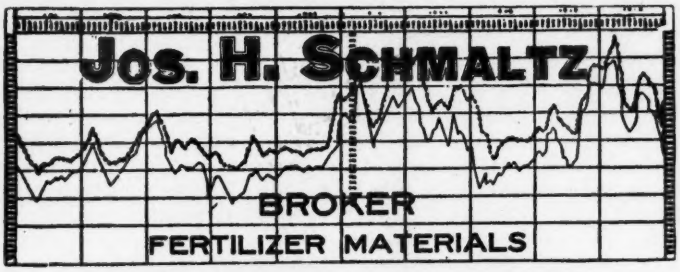
PHOSPHATE ROCK

~ *all commercial grades!*

Plants at Sangully, Pauway, Medulla and Ridgewood, Fla.

MAIN OFFICE • *Baltimore Trust Building* • BALTIMORE, MD.

Tankage
Blood
Bone
All
Ammoniates



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TENNESSEE CORPORATION

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Soluble Mineral Elements
YOU'LL GET *Improved Quality*
with
Manganese SULPHATE
Zinc SULPHATE
Copper SULPHATE
Iron SULPHATE
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Tennessee Corporation
ATLANTA, GA. LOCKLAND, OHIO

ALEX. M. McIVER & SON
Official Brokers for
MILORGANITE
Specializing
CHILEAN NITRATE OF SODA
Nitrogenous Materials
Blood and Fertilizer Tankage
Bone Meals
Manganese Sulphate
SOUTH AMERICAN DRY RENDERED TANKAGE
•
PEOPLES OFFICE BUILDING
Charleston, S. C.

for the study of this problem have been conducted for decades.

The successful use of borax in alfalfa production illustrates a potential effect of minor elements on the agricultural status of a region with particular reference to the southern states. Until a short time ago, all attempts to grow the crop in this area had failed, except on a few of the more productive soil series. As a result of experimentation and observation, it was concluded that the humid climate was unfavorable. Now it appears possible to grow alfalfa satisfactorily throughout the whole range of the eastern states, and the observation that semi-arid regions furnish a more favorable environment seems to relate more to soil than to climatic factors.

New Research Parallel to Liebig's

Whether or not the introduction of these new items into the soil-fertility complex results in extensive changes in agricultural practice, it does broaden the base and increase the flexibility of agriculture, substituting a greater degree of scientific precision for the empiricisms derived from the older types of experimentation.

No longer is it possible to criticize indiscriminately the farmer who fails to succeed. A fairly careful survey of those agricultural regions where social and economic problems are most acute leads to a conclusion that these include the areas where minor element deficiencies are most severe. It now appears that the blame for apparent inefficiency can, in many instances, be charged to the defects of research.

Recognition of the need for minor elements in fertilizers has started a new cycle in agricultural enterprise which is very closely parallel to that introduced by Liebig. It is possible to picture the amazement of the farmers of a century ago when they first noted the effects of the older fertilizers, by observing similar reactions when farmers today see what results can be obtained with boron, copper, or magnesium, on soils which have not previously responded to standard fertilizer treatments.

Prompt acceptance of new developments in agriculture does not seem to be the rule, so many years may pass before the full degree of minor element needs will be recognized and the methods of supplying these needs are perfected. It will be recalled, for example, that one of the principal theses of Liebig's address before the British Association was an attack on the idea sponsored by French scientists that soil humus was the source of the organic components of plants; yet a method for the chemical determinations of soil humus was perpetuated by the Association of Official Agricultural Chemists in this country for three-quarters of a century.

All Fertilizing Elements Needed

Future progress will require not only the adoption of new viewpoints, but also the rejection of fallacies inherent in the logic followed during the past century. Little further advance can be made in soil fertility research under the assumption that only three elements are needed in complete fertilizers. If an attempt is made to include more than three elements in the old type of experiment, however, the plan becomes unwieldy even if the effects of these elements are considered to be independent. If they are in reality dependent variables, the study of a system of more than three components is mathematically impossible.

Only by integrating all of the essential factors can better methods in the use of fertilizers be devised. Leaving some elements out as a matter of convenience in experimentation is incompatible with rational thinking, and fertility problems can best be solved by minimizing the distinction between different groups of elements.

In the 16th century Van Helmont conducted his classical experiment with the willow tree, from which he drew the conclusion that the substance of the tree consisted of a solid form of water. This was found to be erroneous as soon as the principle of photosynthesis was discovered. In a similar way, all experiments will be imperfect to the degree that unrecognized factors influence the result. With this point in mind, an opinion is offered that the recent developments with the minor elements contribute not only to practical objectives in improving agricultural conditions, but also to the perfection of scientific aspects of agronomic research.

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Brokers Fertilizer Materials
ROOM 903
170 Broadway
New York, N.Y.

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the number of pounds of raw material for a desired per cent. of plant food in a ton of mixed goods—or find what per cent. of a certain plant food in a ton of fertilizer produced by a specific quantity of raw materials.

No mathematical calculations are necessary. You can find the figures in a few seconds with the aid of

Adams' Improved Pocket Formula Rule

A Great Convenience for the Manufacturer of High Analysis Goods

To make clearer its use, answers to such problems as the following can be quickly obtained:

How much sulphate of ammonia, containing 20 per cent. of nitrogen, would be needed to give 4½ per cent. nitrogen in the finished product?

Seven hundred and fifty pounds of tankage, containing 8 per cent. phosphoric acid are being used in a mixture. What per cent. of phosphoric acid will this supply in the finished goods?

Should the Adams' Formula Rule become soiled from handling, it may be readily cleaned with a damp cloth.

PRICE $1.00
TO BE SENT WITH ORDER.
Special quotations on twelve or more.

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Sole Distributors

1330 Vine Street :: PHILADELPHIA

BUYERS' GUIDE

A CLASSIFIED INDEX TO ALL THE ADVERTISERS IN "THE AMERICAN FERTILIZER"

This list contains representative concerns in the Commercial Fertilizer Industry, Including fertilizer manufacturers, machinery and equipment manufacturers, dealers in and manufacturers of commercial fertilizer materials and supplies, brokers, chemists, etc.
For Alphabetical List of Advertisers, see page 33.

ACID BRICK
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

ACID EGGS
Chemical Construction Corp., New York City.

ACIDULATING UNITS
Chemical Construction Corp., New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

AMMO-PHOS
American Cyanamid Co., New York City.

AMMONIA—Anhydrous
Barrett Company, The, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.
Hydrocarbon Products Co., New York City.

AMMONIA LIQUOR
Barrett Company, The, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.
Hydrocarbon Products Co., New York City.

AMMONIA OXIDATION UNITS
Chemical Construction Corp., New York City.

AMMONIATING EQUIPMENT
Sackett & Sons Co., The A. J., Baltimore, Md.

AUTOMATIC ELEVATOR TAKEUPS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

BABBITT
Sackett & Sons Co., The A. J., Baltimore, Md.

BAGS AND BAGGING—Manufacturers
Bagpak, Inc., New York City.
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Cotton
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Paper
Bagpak, Inc., New York City.
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS (Waterproof)—Manufacturers
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Dealers and Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

BAGGING MACHINES—For Filling Sacks
Atlanta Utility Works, East Point, Ga.
Bagpak, Inc., New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

BAG-CLOSING MACHINES
Bagpak, Inc., New York City.

BAG PILERS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.

BEARINGS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

BELT LACING
Sackett & Sons Co., The A. J., Baltimore, Md.

BELTING—Chain
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

BELTING—Leather, Rubber, Canvas
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

BOILERS—Steam
Atlanta Utility Works, East Point, Ga.

BONE BLACK
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Huber & Company, New York City.

BONE PRODUCTS
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
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Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

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Pacific Coast Borax Co., New York City.

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Ashcraft-Wilkinson Co., Atlanta, Ga.
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Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

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A Classified Index to Advertisers in "The American Fertilizer"

BUYERS' GUIDE

For an Alphabetical List of all the Advertisers, see page 33

BUCKETS—For Hoists, Cranes, etc., Clam Shell, Orange Peel, Drag line, Special; Electrically Operated and Multi Power
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

BURNERS—Sulphur
Chemical Construction Corp., New York City.

BURNERS—Oil
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CABLEWAYS
Hayward Company, The, New York City.

CARBONATE OF AMMONIA
American Agricultural Chemical Co., New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CARS—For Moving Materials
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CARTS—Fertilizer, Standard and Roller Bearing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

CASTINGS—Acid Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.

CASTINGS—Iron and Steel
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CEMENT—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

CHAIN DRIVES—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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Jeffrey Manufacturing Co., The, Columbus, Ohio.
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Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAMBERS—Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CHEMICAL APPARATUS
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Duriron Co., Inc., The, Dayton, Ohio.
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CHEMICALS
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Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
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CHEMICALS—Continued
Huber & Company, New York City.
Phosphate Mining Co., The, New York City.
Wellmann, William E., Baltimore, Md.

CHEMICAL PLANT CONSTRUCTION
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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Wiley & Company, Baltimore, Md.

CLUTCHES
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CONCENTRATORS—Sulphuric Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CONDITIONERS AND FILLERS
American Limestone Co., Knoxville, Tenn.
Phosphate Mining Co., The, New York City.

CONTACT ACID PLANTS
Chemical Construction Corp., New York City.

COPPER SULPHATE
Tennessee Corporation, Atlanta, Ga.

COTTONSEED PRODUCTS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

CRANES AND DERRICKS
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CYANAMID
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American Cyanamid Co., New York City.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
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Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

DENS—Superphosphate
Chemical Construction Corp., New York City.
Stedman's Foundry and Mach. Works, Aurora, Ind.

Andrew M. Fairlie
CHEMICAL ENGINEER
22 Marietta Street Building ATLANTA, GA.
CABLE ADDRESS: "SULFACID ATLANTA"

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Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

DRIVES—Electric
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DUMP CARS
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ENGINEERS—Chemical and Industrial
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Link-Belt Company, Philadelphia, Chicago.
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Stedman's Foundry and Mach. Works, Aurora, Ind.

ENGINES—Steam
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Link-Belt Company, Philadelphia, Chicago.
Link Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.

FERTILIZER MANUFACTURERS
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American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Farmers Fertilizer Co., Columbus, Ohio
International Agricultural Corp., New York City.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

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Atlanta Utility Works, East Point, Ga.
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GARBAGE TANKAGE
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GEARS—Machine Moulded and Cut
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GEARS—Silent
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GELATINE AND GLUE
American Agricultural Chemical Co., New York City.

GUANO
Baker & Bro., H. J., New York City.

HOISTS—Electric, Floor and Cage Operated, Portable
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Armour Fertilizer Works, Atlanta, Ga.
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IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
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Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
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Hayward Company, The, New York City.
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Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
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Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE
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MIXERS
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Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
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Baker & Bro., H. J., New York City.
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Bradley & Baker, New York City.
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Huber & Company, New York City.
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NITRATE OVENS AND APPARATUS
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NITROGENOUS ORGANIC MATERIAL
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Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
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Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

PIPE—Acid Resisting
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PIPES—Chemical Stoneware
Chemical Construction Corp., New York City.

PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

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Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
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International Agricultural Corp., New York City.
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Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers and Importers
American Potash and Chem. Corp., New York City.
Potash Co. of America, Baltimore, Md.
United States Potash Co., New York City.

PULLEYS AND HANGERS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
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PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
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PYRITES—Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
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Jett, Joseph C., Norfolk, Va.
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Chemical Construction Corp., New York City.

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SEPARATORS—Air
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SEPARATORS—Magnetic
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SHOVELS—Power
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SPRAYS—Acid Chambers
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SULPHATE OF AMMONIA
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TANKAGE
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Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

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UREA-AMMONIA LIQUOR
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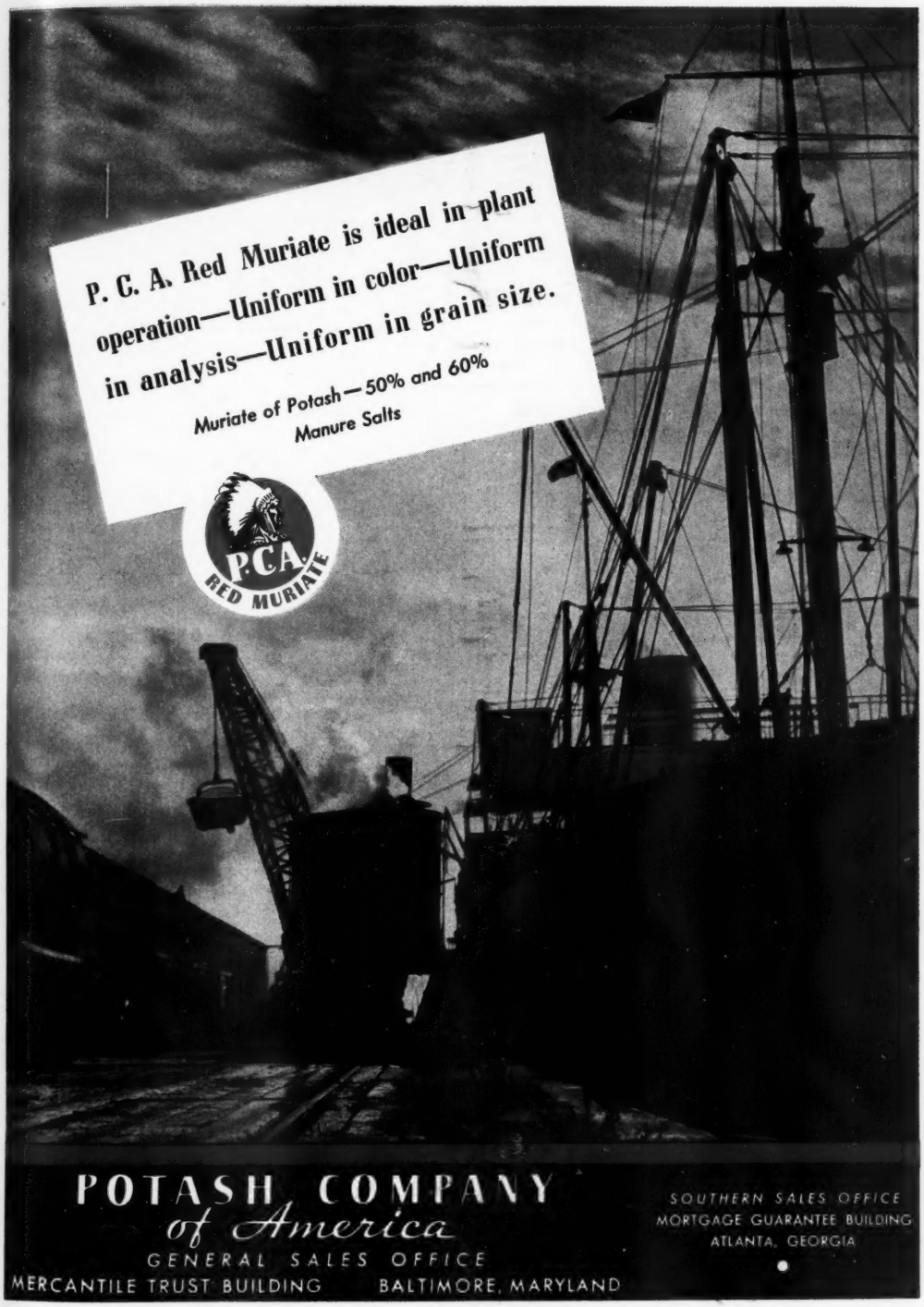
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